

CLAIMS

What is Claimed is:

1. A film surface imprinted with nanometer-sized particles to produce micro- and/or nano-structured electron and hole collecting interfaces, comprising;
 - at least one transparent substrate;
 - at least one photoabsorbing conjugated polymer applied on a first said substrate, wherein said conjugate polymer includes polybutylthiophene (pbT);
 - a sufficient amount of nanometer-sized particles including multiwalled carbon nanotubes (MWNT) to produce a charge separation interface;
 - at least one transparent polymerizable layer including a sol-gel or monomer, said MWNT embedded in said conjugated polymer to produce a mixture and applied on a second said substrate to form a MWNT bearing surface film layer to form a stamp surface;
 - wherein said stamp surface is imprinted into the surface of said polymerizable film layer to produce micro- and/or nano-structured electron and hole collecting interfaces;
 - polymerizing said polymerizable film layer to promote shrinkage to form a conformal gap between said MWNT stamp surface and said surface of said polymerizable film layer; and
 - filling said gap with at least one photoabsorbing material to promote the generation of photoexcited electrons and transport to the charge separation interface.

- 1 2. The film according to claim 1, wherein either said polymerizable layer and said
2 conjugated polymer is applied by processes comprising at least one of spin-coating,
3 dip-coating, spray-coating, flow-coating, doctor blade coating, and screen-printing.

- 1 3. The film according to claim 1, wherein said nanometer-sized particles having
2 average particle sizes of about 1 nm to about 100 nm in diameter and up to about 1
3 nm to about 1 cm in length.

- 1 4. The film according to claim 3, wherein said nanometer-sized particles having
2 average particle sizes of about 1 nm to about 100 nm in diameter and up to about 1
3 nm to about 500 nm in length.

- 1 5. The film according to claim 1, wherein said nanometer-sized particles further
2 comprises at least one of SWNT, and nanocrystals of semiconductor materials.

- 1 6. The film according to claim 5, wherein said nanocrystals of semiconductor materials
2 comprises at least one of CdSe, metal nanowires, and metal-filled carbon nanotubes.

- 1 7. The film according to claim 1, wherein applying said polymerizable film layer
2 ranging in thickness from about 1 nm to about 1 mm.

- 1 8. The film according to claim 1, wherein applying said conjugated polymer mixture
2 ranging in thickness from up to about 100 nm.

1 9. The film according to claim 1, wherein said polymerizable layer comprises at least
2 one monomer film.

1 10. The film according to claim 1, wherein said polymerizable layer comprises at least
2 one sol-gel film.

1 11. The film according to claim 1, wherein said sol-gel includes absolute alcohol and
2 ultrapure water in a ratio of about (1:0.025) and said metal oxide includes titanium
3 oxide and/or zinc oxide.

1 12. The film according to claim 1, wherein said monomer comprising at least one of
2 oxadiazole, aniline, and pyrrole.

1 13. The film according to claim 1, wherein said photoabsorbing material comprises at
2 least one of thermotropic liquid crystalline materials, polybutylthiophene
3 (pbT)/chlorobenzene, and polyelectrolytes.

1 14. A film surface imprinted with nanometer-sized particles prepared by a process to
2 produce micro- and/or nano-structured electron and hole collecting interfaces,
3 comprising:

1 providing at least one transparent substrate;

2 providing at least one photoabsorbing conjugated polymer;

3 providing a sufficient amount of nanometer-sized particles to produce a charge
4 separation interface;
5 providing at least one transparent polymerizable layer including a sol-gel or
6 monomer;
7 embedding said nanometer-sized particles in said conjugated polymer;
8 applying said polymerizable layer on a first said substrate to form a charge
9 transport film layer;
10 applying said conjugated polymer/nanometer-sized particle mixture on a second
11 said substrate to form a nanometer-sized particles bearing surface film layer,
12 wherein said nanometer-sized particles form a stamp surface;
13 imprinting said stamp surface into the surface of said polymerizable film layer to
14 produce micro- and/or nano-structured electron and hole collecting interfaces;
15 polymerizing said polymerizable film layer to promote shrinkage to form a
16 conformal gap between said stamp surface and said surface of said polymerizable
17 film layer; and
18 filling said gap with at least one photoabsorbing material to promote the
19 generation of photoexcited electrons and transport to the charge separation interface.

1 15. The film according to claim 14, wherein said imprinting includes compressing and
2 thereafter, solidifying said stamp surface into said surface of said polymerizable
3 layer.

1 16. The film according to claim 14, wherein said nanometer-sized particles having
2 average particle sizes of about 1 nm to about 100 nm in diameter and up to about 1
3 nm to about 1 cm in length.

1 17. The film according to claim 16, wherein said nanometer-sized particles having
2 average particle sizes of about 1 nm to about 100 nm in diameter and up to about 1
3 nm to about 500 nm in length.

1 18. The film according to claim 14, wherein said nanometer-sized particles further
2 comprises at least one of SWNT, and nanocrystals of semiconductor materials.

1 19. The film according to claim 18, wherein said nanocrystals of semiconductor
2 materials comprises at least one of CdSe, metal nanowires, and metal-filled carbon
3 nanotubes.

1 20. The film according to claim 14, wherein applying said polymerizable film layer
2 ranging in thickness from about 1 nm to about 1 mm.

1 21. The film according to claim 14, wherein applying said conjugated polymer mixture
2 ranging in thickness from up to about 100 nm.

1 22. The film according to claim 14, further comprising electrophoretically depositing
2 said nanometer-sized particles onto said polymerizable layer.

- 1 23. The film according to claim 22, wherein said nanometer-sized particles include
2 TiOx nanometer-sized particles.
- 1 24. The film according to claim 14, wherein said sol-gel includes absolute alcohol and
2 ultrapure water in a ratio of about (1:0.025) and a metal oxide.
- 1 25. The film according to claim 24, wherein said metal oxide comprises at least one of
2 inorganic metal salts and metal organic compounds.
- 1 26. The film according to claim 25, wherein said metal organic compounds include
2 metal alkoxides comprising at least one of titanium isopropoxide and zinc butoxide.
- 1 27. The film according to claim 14, wherein said monomer comprising at least one of
2 oxadiazole, aniline, and pyrrole.
- 1 28. The film according to claim 14, wherein said substrate acts as an electrode by
2 comprising a coating of at least one transparent metal oxide including SnO₂:F,
3 SnO₂:In (ITO), and Au.
- 1 29. The film according to claim 14, wherein said substrate acts as an electrode by
2 comprising a coating of at least one transparent metal oxide being conducting
3 polymers including polythiophenes, polypyrroles, polyanilines, and
4 polybutylthiophenes.

- 1 30. The film according to claim 14, wherein said conjugated polymer includes pbT
2 dissolved in chlorobenzene.
- 1 31. The film according to claim 14, wherein said photoabsorbing material comprises at
2 least one of thermotropic liquid crystalline materials, polybutylthiophene
3 (pbT)/chlorobenzene, and polyelectrolytes.
- 1 32. The film according to claim 14, wherein said substrate comprises at least one of
2 silicon, silicate, plastic, and plastic-like materials.
- 1 33. The films surface imprinted with nanometer-sized particles are obtained by the
2 process defined in claim 14.
- 1 34. The film according to claim 1, wherein said film being utilized in a photovoltaic
2 device or other light guiding device.
- 1 35. A film surface imprinted with nanometer-sized particles to produce micro- and/or
2 nano-structured electron and hole collecting interfaces, comprising;
1 at least one transparent substrate;
2 at least one photoabsorbing conjugated polymer applied on a first said substrate,
3 wherein said conjugate polymer includes polybutylthiophene (pbT);
4 a sufficient amount of nanometer-sized particles including multiwalled carbon
5 nanotubes (MWNT) to produce a charge separation interface;

6 at least one transparent polymerizable layer including polymer,
7 said MWNT embedded in said conjugated polymer to produce a mixture and
8 applied on a second said substrate to form a MWNT bearing surface film layer to
9 form a stamp surface;

10 wherein said stamp surface is imprinted into the surface of said polymerizable
11 film layer to produce micro- and/or nano-structured electron and hole collecting
12 interfaces;

13 polymerizing said polymerizable film layer to promote shrinkage to form a
14 conformal gap between said MWNT stamp surface and said surface of said
15 polymerizable film layer; and

16 filling said gap with at least one photoabsorbing material to promote the
17 generation of photoexcited electrons and transport to the charge separation interface.

1 36. The film according to claim 35, wherein said polymer comprising at least one of
2 nitrogen containing heterocycle(s) and polyaniline.